STATE OF CALIFORNIA
HIGHWAY TRANSPORTATION AGENCY
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

AN EXPERIMENTAL GLARE SCREEN INSTALLATION ON U. S. 101 IV-MRN-1-C BETWEEN TAMALPAIS ROAD AND CORTE MADERA CREEK

A STUDY MADE BY THE
CALIFORNIA DIVISION OF HIGHWAYS
IN COOPERATION WITH THE
U.S. DEPT. OF COMMERCE
BUREAU OF PUBLIC ROADS

March 1965

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State of California
Highway Transportation Agency
Department of Public Works
Division of Highways
Materials and Research Department

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Mr. J. C. Womack
State Highway Engineer
California Division of Highways
Sacramento, California

Dear Sir:

Submitted for your consideration is a report on:

AN EXPERIMENTAL GLARE SCREEN INSTALLATION

ON

U. S. 101 - IV-Mrn-1-C

BETWEEN TAMALPAIS ROAD AND CORTE MADERA CREEK

Study made by . . . . Structural Materials Section
Under general supervision of . . . . E. F. Nordlin
Work supervised by . . . . R. N. Field
Report prepared by . . . . R. N. Doty and C. R. Ledbetter

Very truly yours,

John L Beaton

JOHN L. BEATON
Materials and Research Engineer

RND/CRL:mw
cc: LRGillis
GAHill
ASHart
CGBeer
ACEstep
JEWilson

I. INTRODUCTION

When traveling on many of today's modern highways, the motorist must travel with his headlights on high beam to utilize the full sight distance available to him. Because of the objectional glare to which the oncoming motorist is subjected during this type of travel, some form of headlight glare screen is becoming necessary.

Several types of glare screen are in use today, the most common on California's highways being shrubbery. Wood or metal fences placed parallel to the centerline of the highway and intermittent wood and metal fences placed in a louvered pattern or 90° to the centerline of the highway are also being used, as are corrugated plastic panels.

In order to evaluate the effectiveness of several other types of material for use as headlight glare screens, an installation consisting of 1000 feet of each of six different types of glare screen on a State of California contract near Oakland was proposed in January 1962. Due to an unavoidable delay in the procurement of the required funds for the Oakland contract, it was later decided to install 5,957 feet of glare screen, composed of six different types of screen material, on Highway 101, Road IV-Mrn-1-C, C Mad, between 0.2 miles south of Tamalpais Road Interchange and Corte Madera Creek, north of San Francisco, Calif. The work was done by contract and supervised by State of California Division of Highways District 04 personnel.

The following types of glare screens mounted on the Standard California cable-type median barrier were proposed for testing:

1. Chlorosulfonated polyethylene coated nylon webbing to be woven horizontally in the two inch galvanized steel chain link mesh (see Exhibit 1).

2. Polypropylene webbing to be woven horizontally in the chain link mesh (see Exhibit 2).

3. Prepainted aluminum slats to be inserted vertically and at a 45° angle in the chain link mesh (see Exhibit 3).

4. Amorphous phosphate-chromate (Alodine) color treated aluminum slats to be inserted vertically in the chain link mesh (see Exhibit 4).

5. Expanded galvanized steel in lieu of chain link fabric, retaining the cable feature of the barrier (see Exhibit 5).

6. Expanded prepainted aluminum in lieu of chain link fabric, retaining the cable feature of the barrier (see Exhibit 6).

The objectives of this test series were:

1. To test the effectiveness of each type as a headlight glare screen.

2. To test the durability of each type in a coastal environment.

3. To determine the relative maintenance costs and ease of replacement of damaged sections.

4. To obtain valid initial costs for each type of glare barrier.

A seventh type of glare screen consisting of prepainted roll-formed aluminum channels inserted vertically in the chain link fabric was added by the District 04 maintenance forces adjacent to the test site, for evaluation (see Exhibit 7).

The contractor was Wulfert Company, Incorporated, P. O. Box 190, Pleasanton, California.

II. SUMMARY AND RECOMMENDATIONS

The evaluations of the seven types of glare screen are listed in Table I below:

TABLE I

TYPE		LENGTH IN FEET	EFFECTIVENESS OF GLARE SCREEN	DURABILITY	RELATIVE MAINTENANCE COST H L 1 2 3 4 5	EASE OF REPLACEMENT	AVERAGE COST PER FOOT OF CONSTRUCT. GLARE SCREEN-BARRIER COMBINATION	AVERAGE COST PER FOOT OF ADDING GLARE SCREEN PROTECTION TO EXISTING CABLE-CHAIN LINK MEDIAN BARRIER	AVAILABILITY
ROLL FORMED PREPAINTED ALUMINUM CHANNEL		24	GOOD	GOOD	4	FAIR	$3.89	$1.25	STOCK
PREPAINTED EXP AL. (INTERSTATE GREEN)		941	GOOD	GOOD	5	GOOD	3.94	1.61	STOCK
GALVANIZED EXP. STEEL		1000	GOOD	GOOD	5	GOOD	4.38	2.05	STOCK
POLYPROPYLENE WEBBING		1000	FAIR	FAIR	1	POOR	5.27	2.63	SPECIAL ORDER
NYLON WEBBING		1016	FAIR	POOR	1	POOR	5.72	3.08	SPECIAL ORDER
PREPAINTED ALUMINUM SLATS	VERTICAL	500	POOR	GOOD	3	POOR	6.67	4.03	SPECIAL ORDER
	DIAGONAL	1000	FAIR	GOOD	2	POOR			
ALODINE COLOR TREATED ALUMINUM SLATS		500	POOR	POOR	3	POOR	7.14	4.50	SPECIAL ORDER

NOTE: THE AVERAGE BID PRICE FOR THE CABLE-CHAIN LINK MEDIAN BARRIER WAS $2.64 PER FOOT.

The prepainted expanded aluminum appears to be the most desirable type of glare screen. The prepainted material is sufficiently resistant to corrosion and offers a pleasing and uniform appearance. It is available in any of 20 standard colors in minimum quantities of 2500 lineal feet. The mesh in the Interstate green color used for this project is a stock item and is available in any quantity. The mesh does not decrease the effectiveness of the cable type barrier in any way (see Exhibit 8). An added advantage that the expanded metal has over the slats and webbing is that while the expanded metal screen will permit no light to penetrate at viewing angles of approximately 30° and less with the screen, the visibility through the barrier at a viewing angle of 90° with the screen is virtually unrestricted (see Exhibit 9).

It is the recommendation of this department that the prepainted expanded aluminum mesh be used for glare screens in all locations requiring glare protection on a cable type median barrier. The expanded metal sheets can also be fastened to existing chain link fabric in locations having the cable type of median barrier. Repairs to the barrier should be made with sections of the expanded aluminum only. Exhibit 10 is a tentative specification for prepainted expanded aluminum mesh.

III. STUDY PROCEDURE

The installation of the six types of glare screen was done by contract and supervised by the Division of Highways District 04 personnel. The district resident engineer was Mr. Carter C. Reaves. The field observations included day and night visual inspections and both still and motion pictures taken during day and night.

Close observation was made by District 04 construction personnel during erection of the screens to determine the relative ease of installation.

Information on maintenance problems was supplied by maintenance personnel in District 04.

IV. DISCUSSION

It has been found that "the effectiveness of the cable-type barrier in retaining a high speed impacting vehicle is not materially affected by deletion of the chain link mesh from the system", (Reference 1). Reference 1 further states that it is "probable that the chain link mesh provides a psychological assurance to some motorists that a positive barrier does in fact exist. Therefore, should the chain link mesh be deleted, particularly on a narrow median, some type of screening material could be substituted for the mesh. This screening may be in the form of plantings, expanded metal or other metallic or plastic materials." Thus, the efficiency of the cable-type median barrier would not be affected by the addition of any of the glare screen materials tested.

All seven screening materials were effective in reducing headlight glare to some extent when properly installed. The ability of the nylon webbing to adequately prevent glare from the headlights of approaching vehicles after an extended period of service might be impared by its tendency to curl, thus forming gaps between the webs (see Exhibit 11). These gaps in the webbing allow a distracting but not disabling amount of glare to be transmitted into the driver's eye. The polypropylene webbing did not curl or sag noticeably after five months as the nylon webbing did. However, extended periods of service with greater temperature variations might cause excessive curl or sag to develop, thus decreasing the efficiency of the barrier in providing glare protection.

The effectiveness of the prepainted and amorphous-chromate color-treated aluminum slats was decreased because of the inability to eliminate the flicker caused by the headlight beam passing between them. Although the vertical slats reduce headlight glare, the flicker can be objectionable due to the distracting effect it has on the driver. The flicker is less noticeable for the slats inserted at the 45° angle with the median surface but is still great enough to be objectionable.

The expanded aluminum eliminates all the light transmitted by the headlights of opposing vehicles for the critical viewing angles of less than 30° with the screen. The possibility of unobstructed vision through the glare screen at angles approaching 90° makes travel more pleasant for the motorist and is of extreme value to law enforcement personnel.

Very little corrosion was evident on the metallic types of screen with the exception of the amorphous phosphate-chromate color-treated aluminum slats, which were moderately corroded after approximately five months of service in this coastal environment (see Exhibit 12). These amorphous phosphate-chromate color-treated aluminum slats appeared to be the most susceptible to corrosion, but their effectiveness as a glare screen was not hindered by this in the current short five month exposure. It appears, however, that corrosion could develop into a maintenance problem for this material after an extended period of time in a coastal environment.

The cut edges of all the other precoated metallic materials are the most susceptible to corrosion. The possibility of the need for further protection of these uncoated edges was not determined, but methods may have to be developed if edge corrosion becomes a problem with longer exposure. After this five month observation period, no edge corrosion was visible on either the galvanized steel or the prepainted aluminum expanded metal fabric.

Nylon webbing does not appear to be as durable as the polypropylene webbing. The nylon webbing faded objectionably and curled and stretched during this short observation period. After five months, there was little noticeable fade, and very little curl and sag in the polypropylene webbing. However, this material may also develop an undesirable amount of curl or sag after a longer exposure period.

The cost of replacement of the aluminum slats and the webbing is very high. The requirement imposed by the insertion of slats or weaving of webbing in the chain link mesh greatly increases the amount of time required to make repairs on the barrier. Because the safety of the maintenance personnel while repairing the barrier is of great importance, it is desirable to minimize the time the crews are exposed to the hazardous condition of working in the median area. The vertical slats or webbing can be pre-inserted in the mesh, but this would require unrolling the chain link fabric in the maintenance yard, inserting the slats or webbing, and rerolling the chain link fabric, thus increasing the cost of the labor required to repair a section.

Field splices in the webbing present an unsightly appearance and are difficult to make (see Exhibit 13). The roll formed aluminum channel presents a pleasing appearance and creates no maintenance problems other than the time required for inserting the slats. The flat aluminum slats installed at the 45^{o} angle also give a pleasing appearance, but are more difficult to install than the vertical slats, particularly at posts, where the slats must be inserted under the tie wires.

The flat aluminum slats inserted vertically present a slightly irregular appearance due to the inability to obtain an adequate fit when inserting them in the chain link mesh (see Exhibit 14). The dimensions in the wire mesh generally tend to vary slightly, thus necessitating special purchase ordering of the aluminum slats to get good slat fit. The width of the slat is critical because edge contact with the wire mesh determines the pitch of the slat. If the slat is too narrow, the fit is loose and the pitch of the slats will not be constant. If the slat is too wide, the problem of insertion is compounded greatly.

The uniformity of the expanded aluminum mesh is good. The installation of an overlay of expanded aluminum on existing chain link fabric should present no operational problems. Expanded metal panels have been attached to the cables and tension wire with 10 gauge aluminum wire or hog rings with both methods proving entirely satisfactory. Panel attachment to the posts can be accomplished with either stainless steel bands or 7 gauge aluminum tie wire. Although both are adequate, material and labor costs for installing the bands would be higher. Care should be taken when installing the panels to insure an even upper edge (see Exhibit 15) and to minimize tension in the panels. When repairs are required on sections of median barrier that have the expanded aluminum overlay on the chain link fabric, only the expanded aluminum should be replaced.

Although the galvanized expanded steel has all the features of the expanded aluminum, it is slightly heavier and somewhat more expensive than its aluminum counterpart. It also would be expected that the bare edges of the expanded aluminum would offer greater resistance to critical long term corrosion than the bare edges of the galvanized steel.

As shown in the bid prices averaged in Table I, the initial cost of the expanded metal is significantly cheaper than the other types of glare screen tested with the exception of the roll formed aluminum channel in chain link mesh. Although the labor portion of the cost of installation of the expanded metal is not available, it should prove to be less than for any of the other types of screen tested. Thus, not only is the initial cost of the expanded metal glare screen-barrier combination less but the cost of installing the expanded metal over existing cable-chain link barriers should be cheaper than for the other glare screen materials tested. The initial cost of placing aluminum channel in chain link mesh is competitive with the expanded metal, but the cost of maintenance would be significantly greater because the cost of replacing chain link mesh would always have to be included.

The bids of the four bidders on this contract were averaged for the separate items due to the large variation in the item bid prices (see Exhibit 16). The primary reason for this variation in item bid prices was probably due to the lack of experience on the part of the contractors with this type of installation. There were also some problems in locating sources and prices for the various glare screen materials specified. Subsequent installations of each of the screens tested would be somewhat less expensive, but experience with the maintenance of these screens indicates that the decrease would be insignificant, due to the high cost of labor alone.

The bottoms of the four foot wide glare screens were installed 12 inches above the 6 inch high raised median surface.

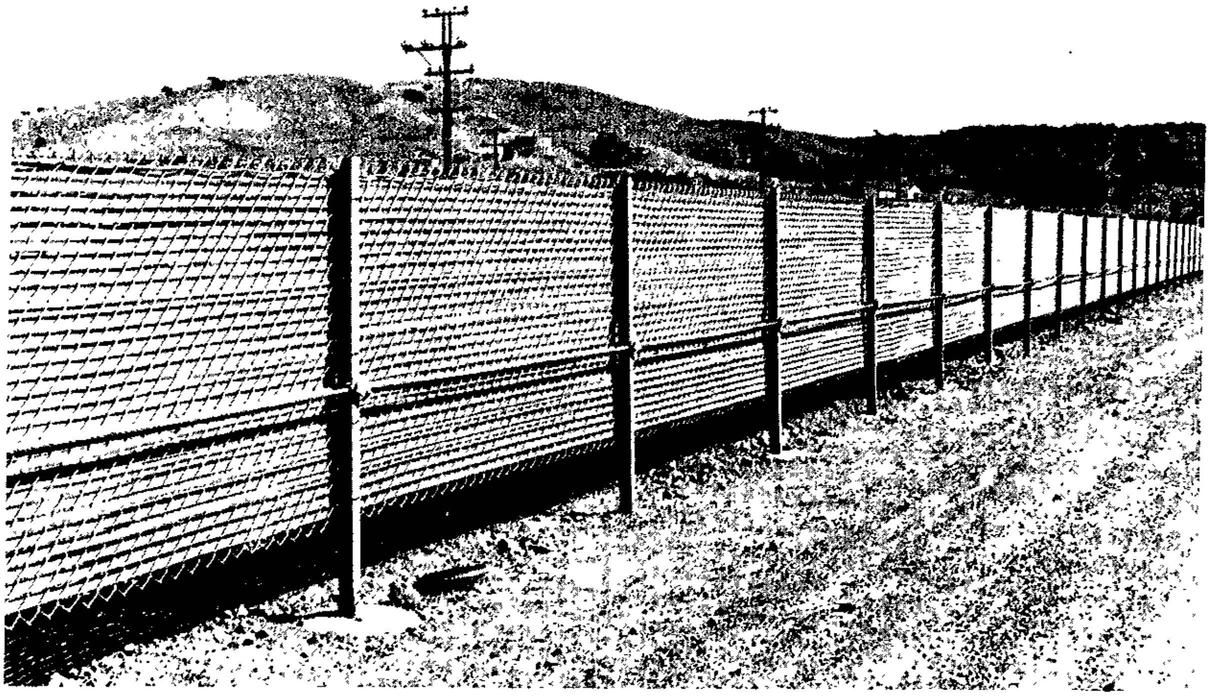
This provided glare protection for heights up to 66 inches above the traveled way, and placed the lower edge of the glare screen approximately 18 inches above the pavement which appears to be satisfactory on constant grades.

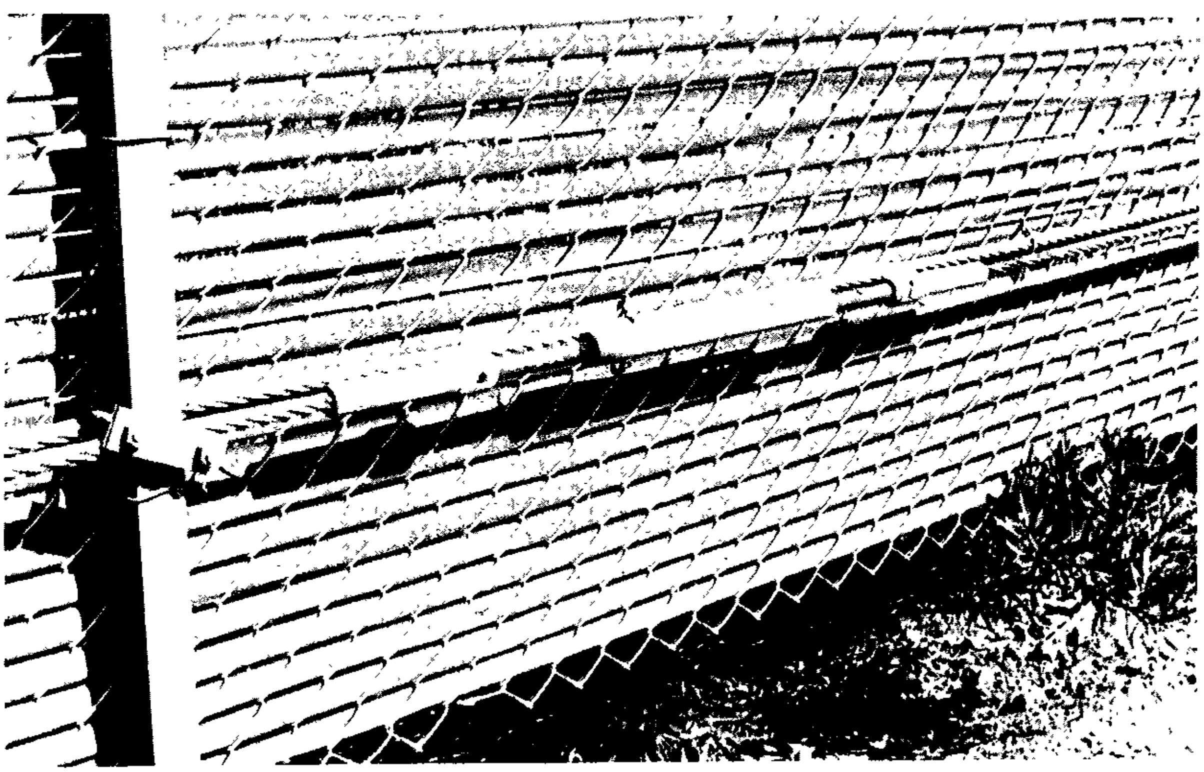
A further study has been initiated to determine the minimum median width for which glare protection should be provided. Studies on the effect vertical curves have on the hazard of glare from oncoming vehicles may also be necessary to determine what variations should be made in the dimensions of the glare screen to insure adequate glare protection in these locations.

V. REFERENCES

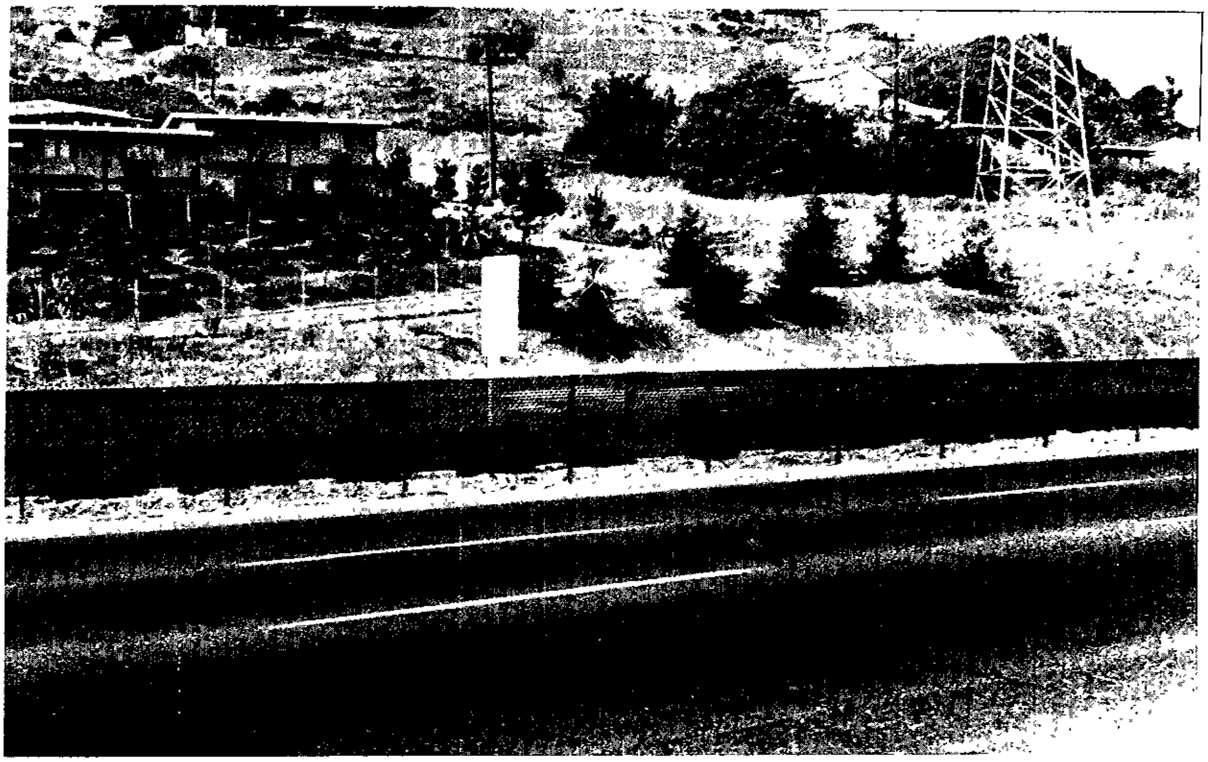
1. Beaton, J. L., R. N. Field, and K. Moskowitz, Median Barriers - One Year's Experience and Further Controlled Full Scale Tests. Presented at the 41st Annual Meeting of the Highway Research Board, January 1962.

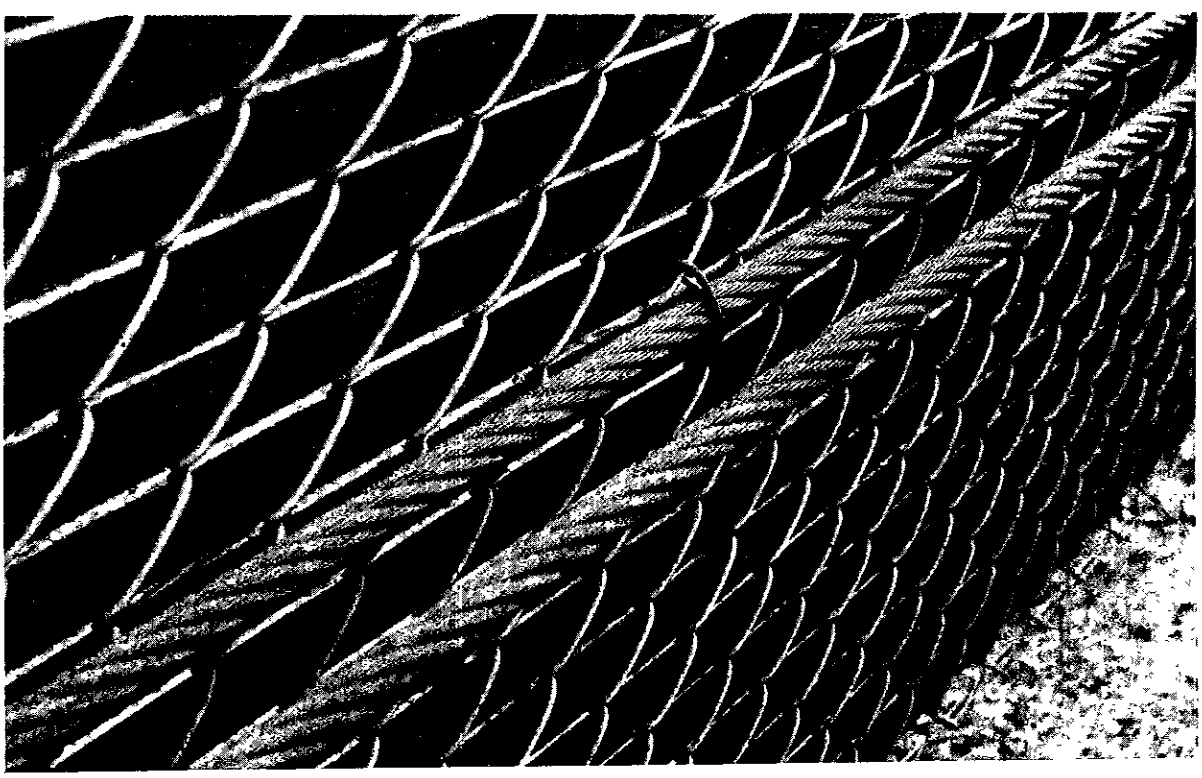
2. Beaton, J. L., E. F. Nordlin, and R. N. Field, Dynamic Full Scale Impact Tests of Cable Type Median Barriers, Test Series VII. March 1964.



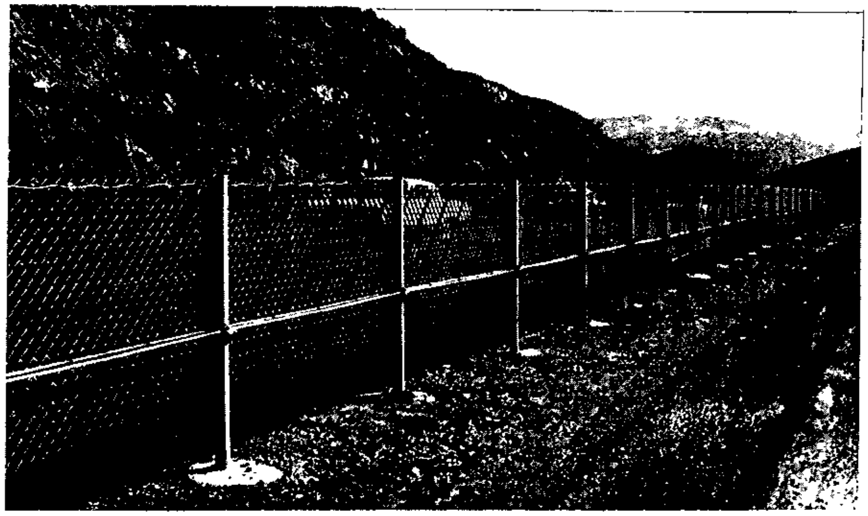


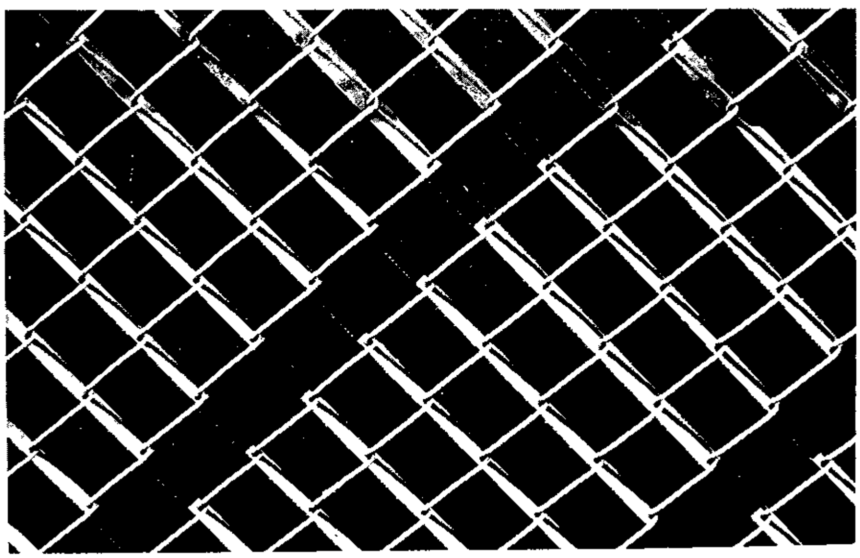
CHLOROSULFONATED POLYETHYLENE
COATED NYLON WEBBING

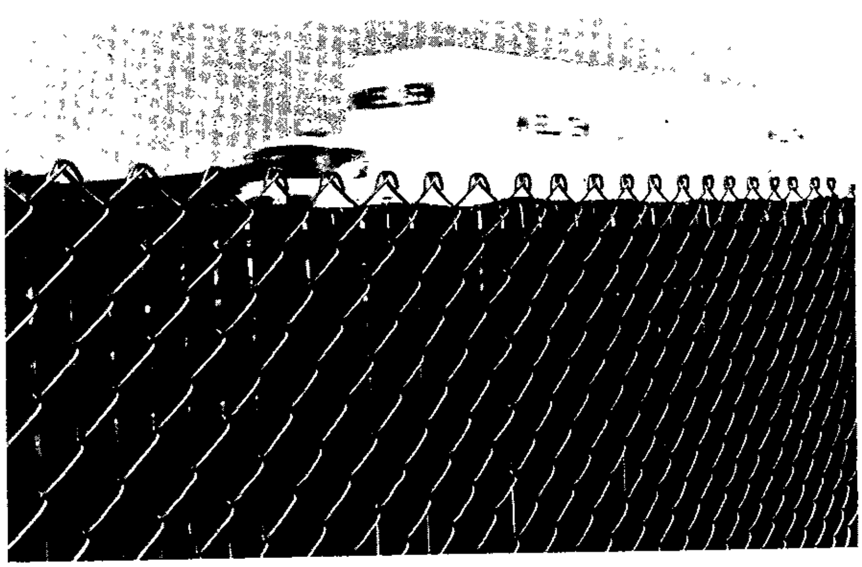




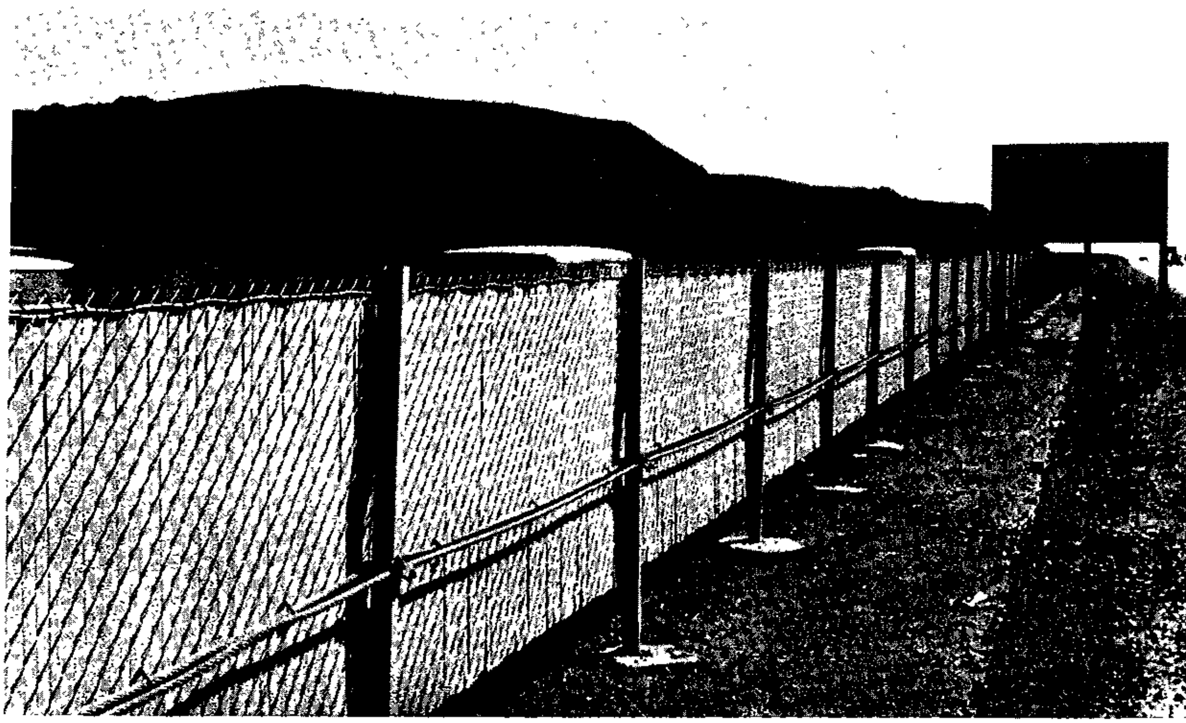
POLYPROPYLENE WEBBING

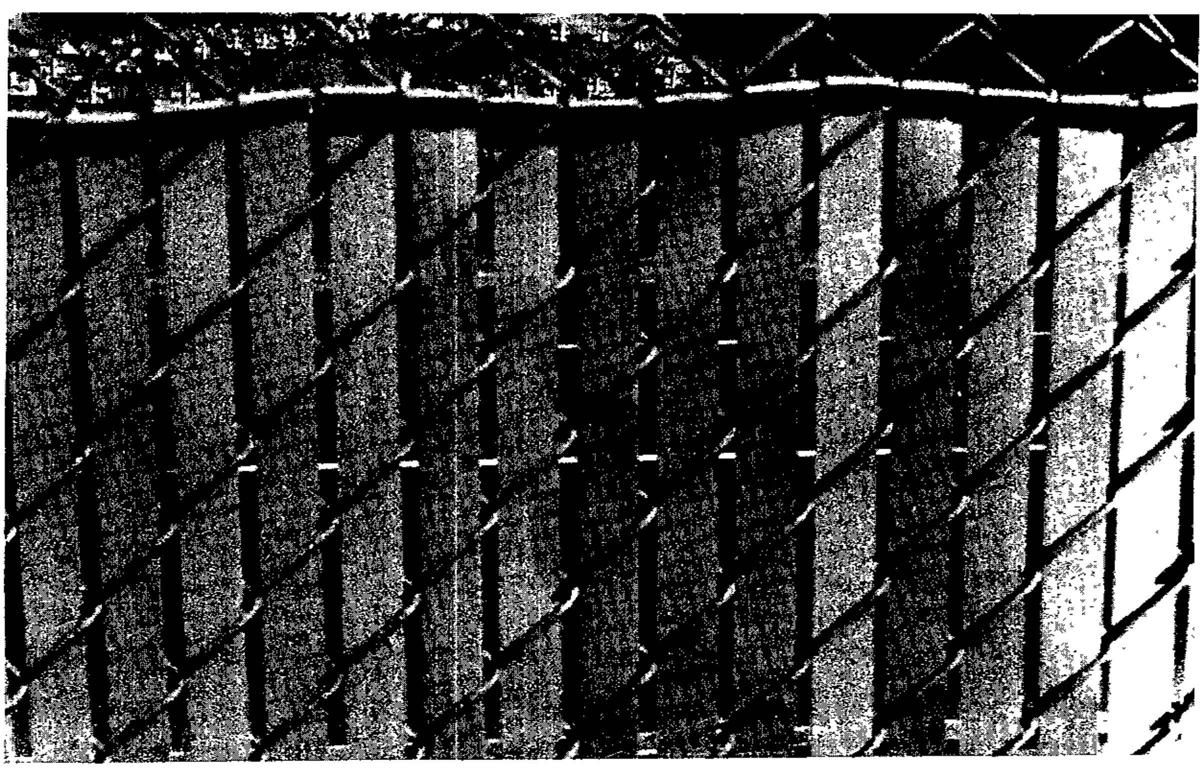




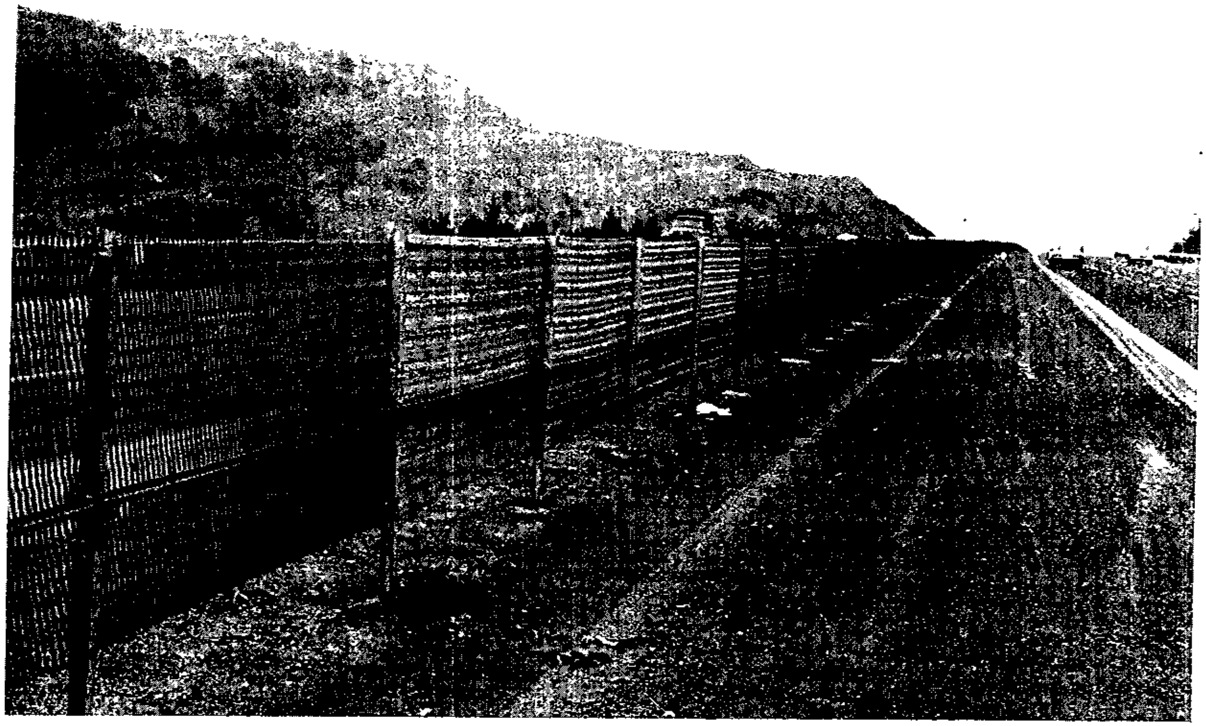


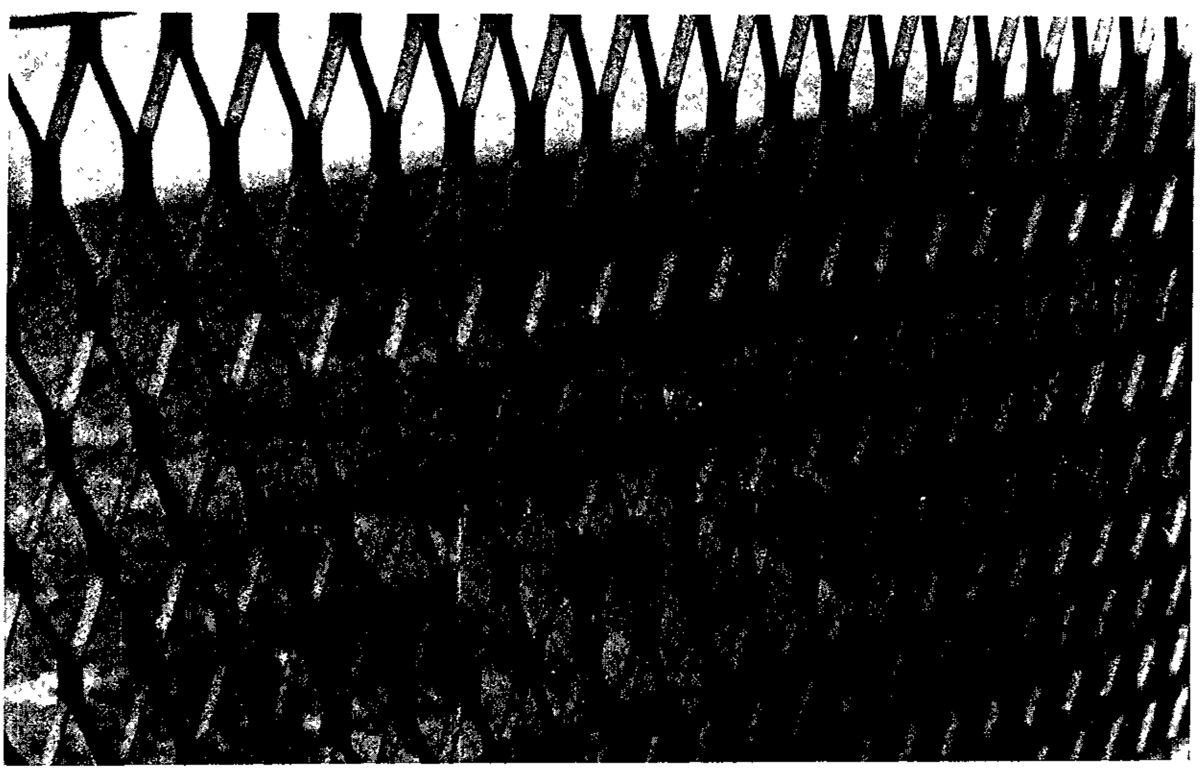
PREPAINTED ALUMINUM SLATS



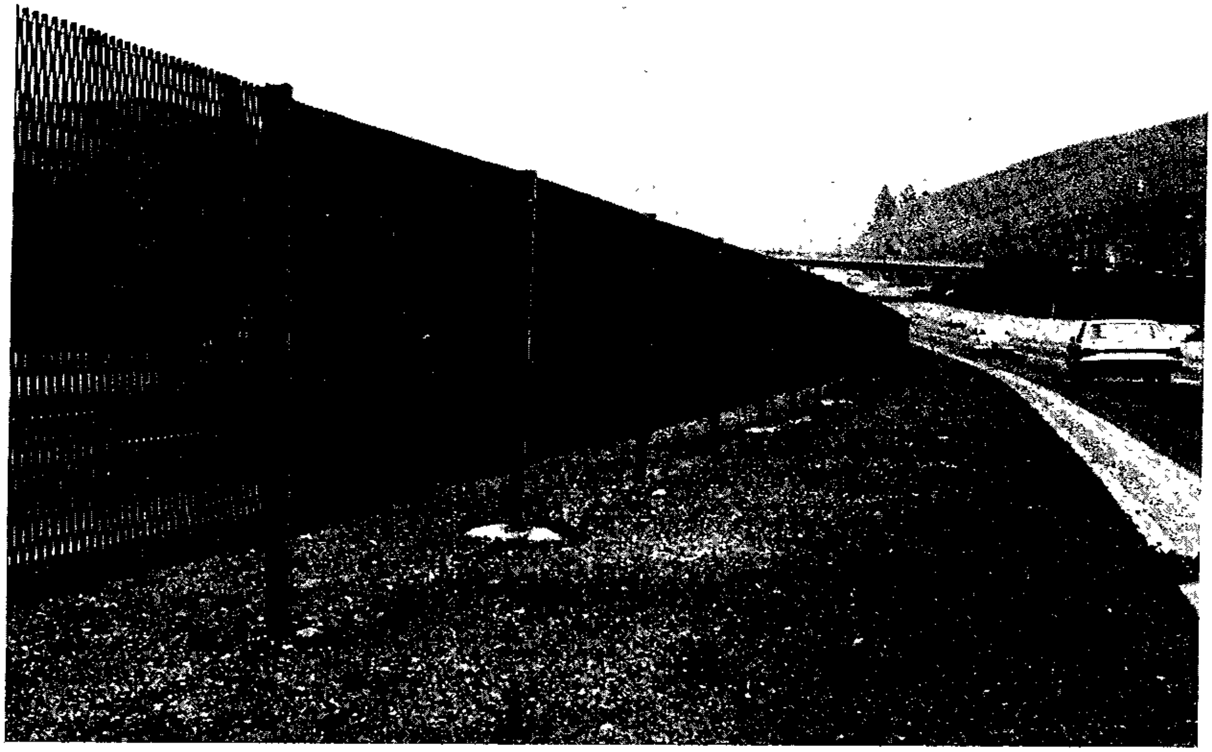


AMORPHOUS PHOSPHATE CHROMATE
("Alodine")
COLOR-TREATED ALUMINUM SLATS

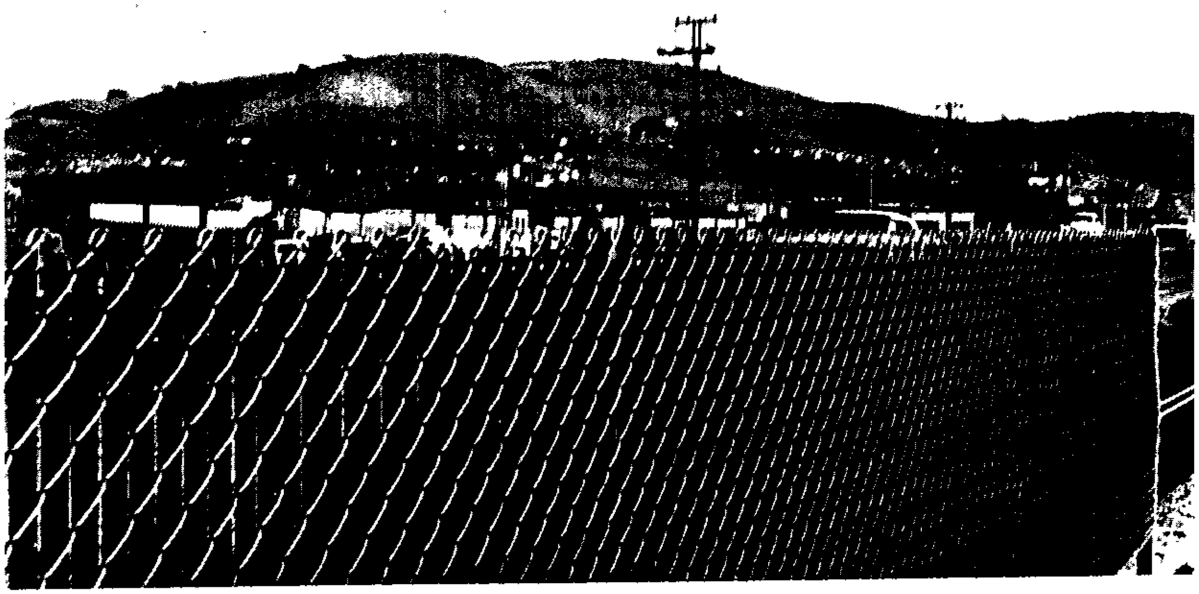


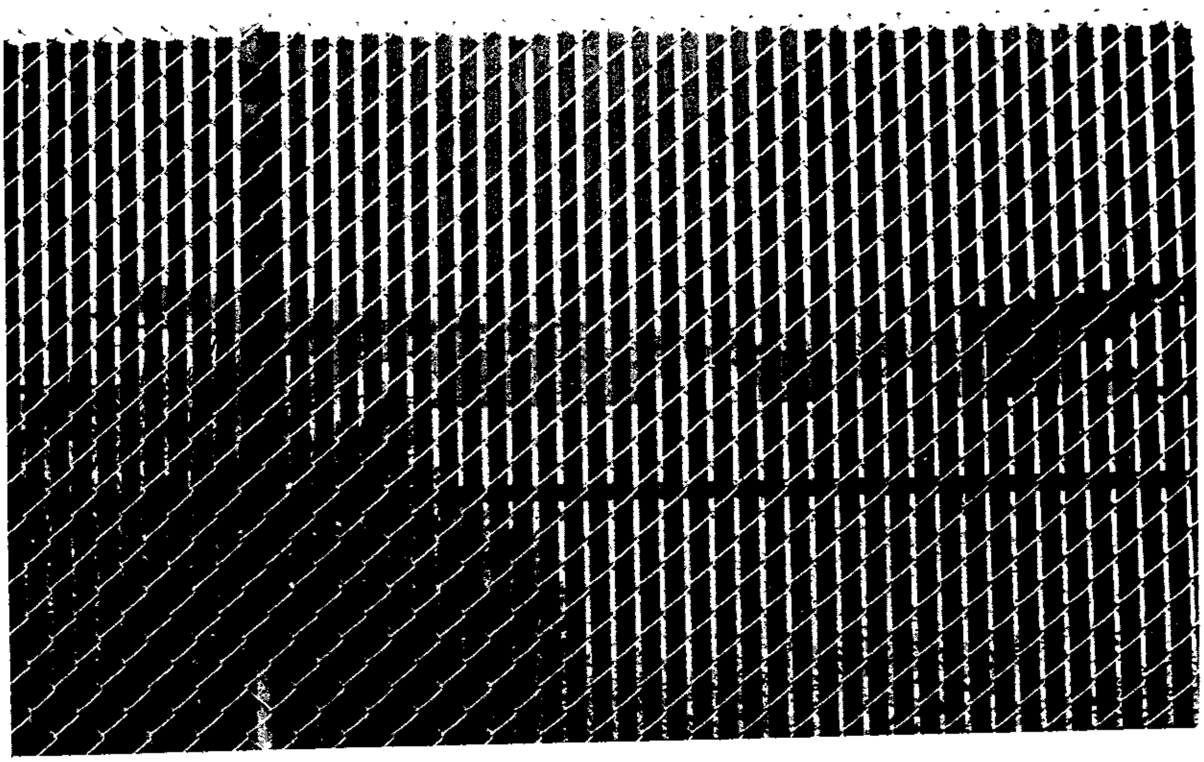


EXPANDED GALVANIZED STEEL



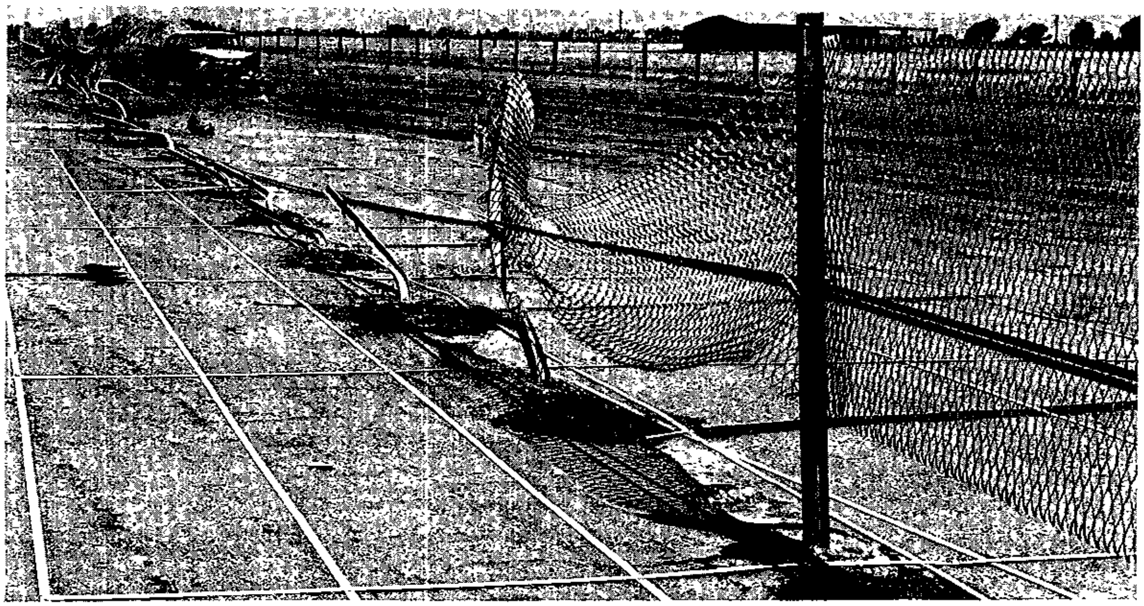
EXPANDED PRE-PAINTED ALUMINUM





PRE-PAINTED ROLL FORMED ALUMINUM CHANNEL

DYNAMIC FULL SCALE IMPACT TEST ON CABLE-TYPE MEDIAN BARRIER WITH EXPANDED STEEL MESH TESTED IN JULY 1961 DURING SERIES VI



TEST NO. 6

Fabric: Expanded steel mesh on impact side of barrier. "U" of cable clamp on impact side. Fabric not contained by cables. Fabric 18 gage galvanized steel, 1.33 inch x 3 inch diamond, 8 foot 4 inch x 42 inch panels.

Cable: 2 each 3/4 inch - 6 x 19 IWRC @ 30 inches above pavement.

Post Footing: Type "C" 8 inch x 12 inch PCC (see Exhibit 3).

Purpose: To test effectiveness during collision of expanded metal fabric compared to previous tests on chain link fabric. Also a re-test on the 8 inch x 12 inch concrete collar type post footing.

Performance: See Exhibit 9. All wheels remained on pavement throughout run with a very slight yawing of vehicle. Post No. 11 pulled out of footing; however, there was no measurable change in vehicle reaction when compared to Test No. 2 on 8 inch x 30 inch PCC footings. The expanded metal fabric reacted very similarly to chain link fabric under identical collision conditions. Very smooth deceleration to 160^{o} spin-out at approximately 80 feet from impact.

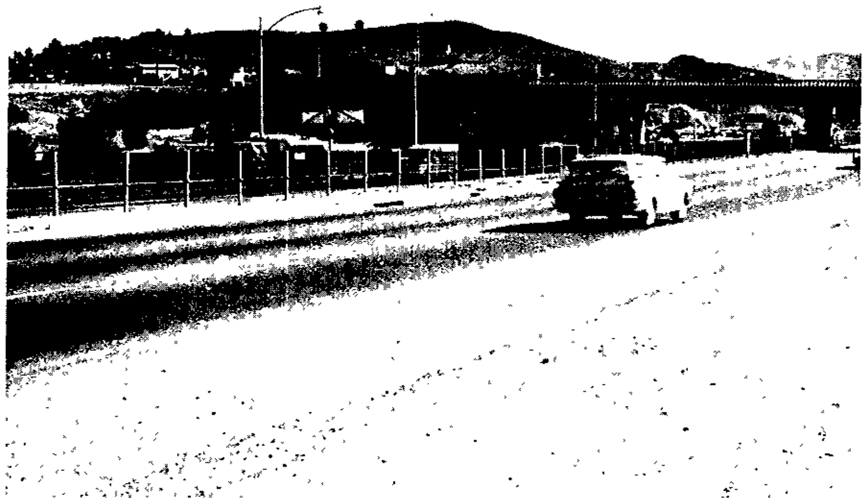
Maximum encroachment on traveled side: 18 feet.

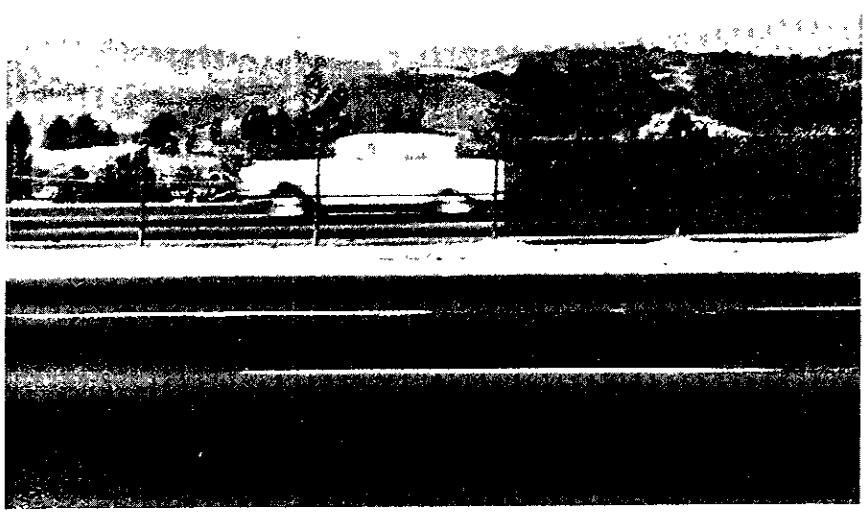
Maximum encroachment on opposing side: 6 feet.

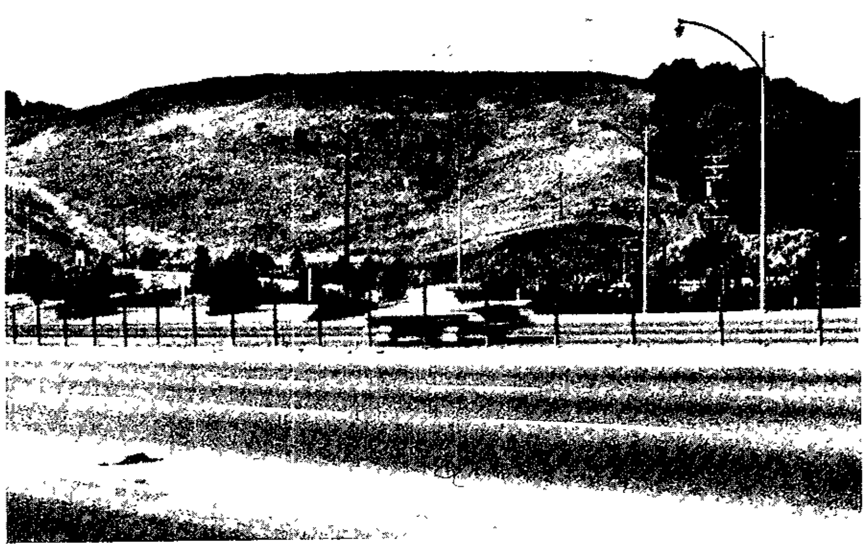
Opposing side 4 foot encroachment for 4/10 seconds.

Opposing side 5 foot encroachment for 3/10 seconds.

Barrier Damage: Fourteen panels (112 feet) of expanded metal gathered up at point of spin out. The severe cracking of all post footings in the collision zone and complete failure of one was due to "green" concrete.







UNRESTRICTED VIEW THROUGH EXPANDED ALUMINUM

STATE OF CALIFORNIA--DIVISION OF HIGHWAYS

SPECIFICATION FOR EXPANDED ALUMINUM HIGHWAY GLARE SCREEN WITH INTERSTATE GREEN FINISH

(TENTATIVE)

The expanded aluminum mesh panels shall conform to the Aluminum Association Alloy Designation 3105-H25 Temper and to the provisions of ASTM Designation: B 209-62. The expanded aluminum mesh panels shall conform to the following nominal dimensions:

Diamond size	1.33" shortway of diamond (center to center of bridges) 4.0" longway of diamond (center to center of bridges)
Strand size	0.050" thickness 0.250" strand width
Panel size	4.0" (LWD) x 8'5" (SWD) Other sheet sizes available for special requirements
Weight per square foot	0.21 pound minimum

The finish for the aluminum mesh panels shall be one coat of 1st quality, high temperature baking enamel, made with a combination of alkyd, vinyl, and amino resins, or equivalent materials formulated for roller coating application. This finish shall be applied on both sides before fabrication in the color specified.

The colored enamel finish for the aluminum mesh shall be Interstate Green unless otherwise specified. When Interstate Green is specified, the chromaticity limit of the enamel finish coat shall be within the California Division of Highways Chart No. 23. The chromaticity measurements shall be made in accordance with Test Method No. California 660-A. The baked enamel finish shall be uniform throughout and shall be smooth and free from flow lines, streaks, blisters or other surface imperfections.

The metal surface shall be treated, in power washing equipment, and with a chemical conversion coating conforming with the requirements of Federal Specification MIL-C-5541, Chemical films for aluminum and aluminum alloys.

The composition of the enamel film shall be such that the dried film properly baked will meet the following requirements:

1. Thickness:

   Dry film thickness shall be 0.8 mil minimum.

   The paint thickness shall be determined by ASTM Method D 1400-56T.

2. Gloss:

The gloss of the enamel shall be standard medium gloss (60° specular gloss 70 minimum when tested according to Federal Test Method Standard #141 Method 6101).

3. Color Uniformity:

The color uniformity of the enamel after baking shall be constant within commercial limits when checked visually in the Macbeth Daylight Booth.

4. Coating Adhesion:

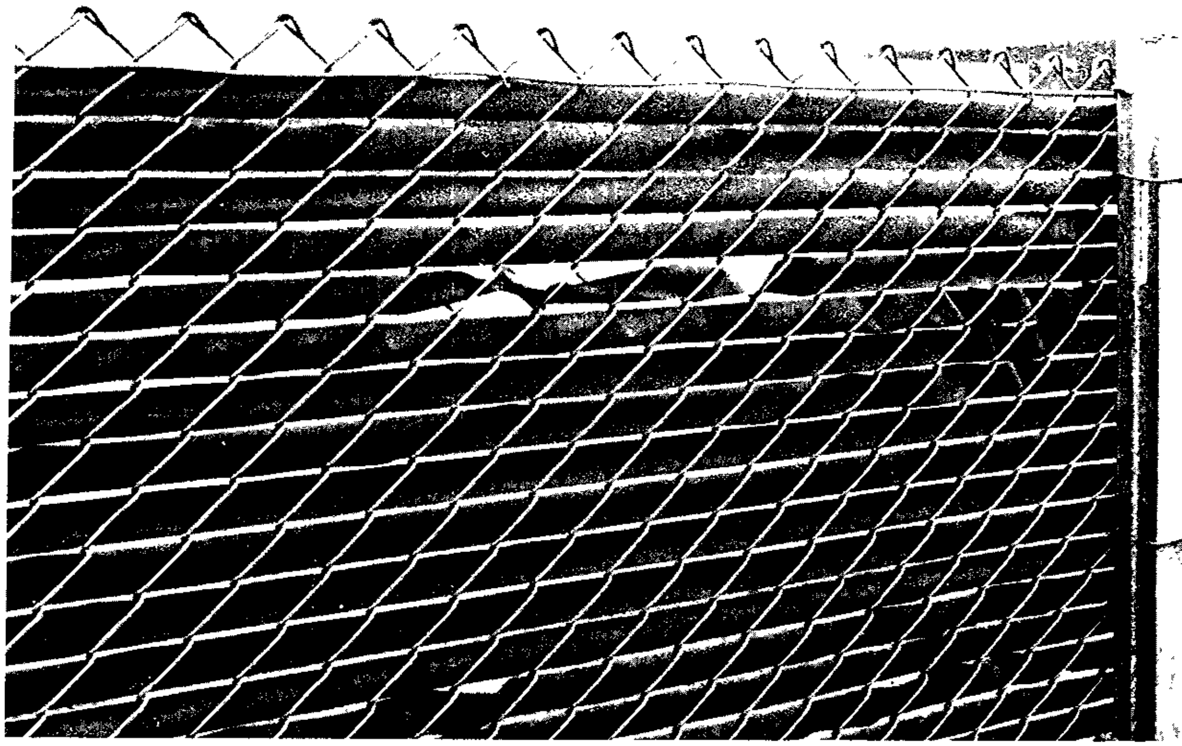
Paint adherence shall conform to Test Method No. California 645-A, and a 4" x 8" sample of the sheet, before expansion, shall be submitted for testing.

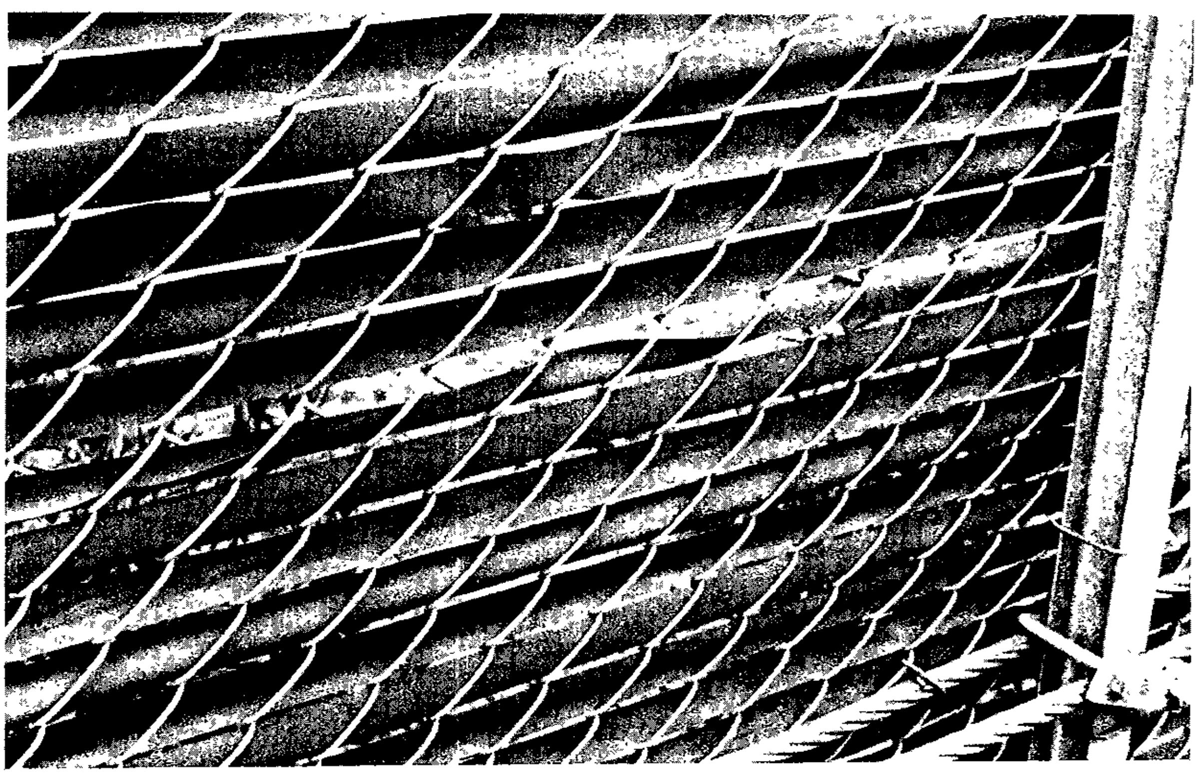
There shall be no loss of adhesion of the coating to the base metal during or after fabrication of the expanded metal panels.

The expanded metal fabric shall be tied to the top tension wire and to the cable at approximately 24 inch intervals with 0.120 inch minimum diameter (11 gauge) aluminum or steel wire ties or hog rings. The fabric shall be tied to the posts at approximately 15 inch intervals, starting 2 inches from the top of the fabric, with 0.150 inch minimum diameter (9 gauge) aluminum or steel wire ties.

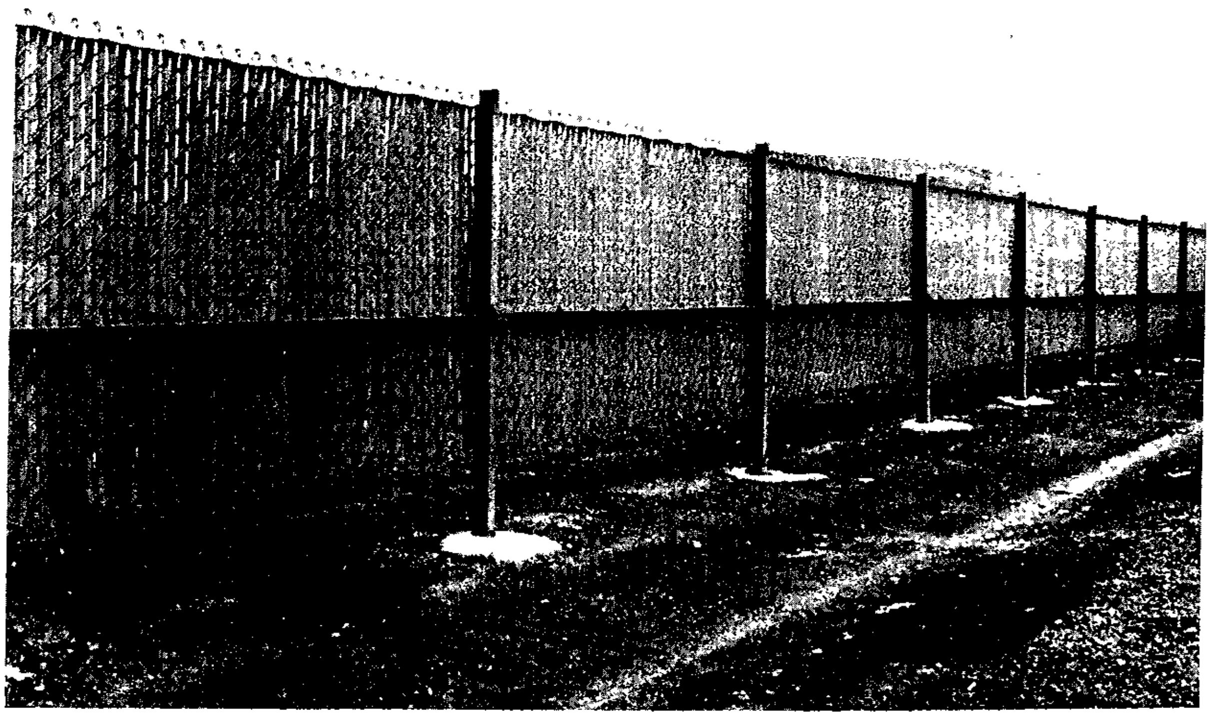
The aluminum wire shall conform to ASTM Designation: B 211, Aluminum Alloy 1100-H18. Aluminum alloy 6061-T94, 5052-H38, or Alclad 5056-H38 shall be used for aluminum hog rings.

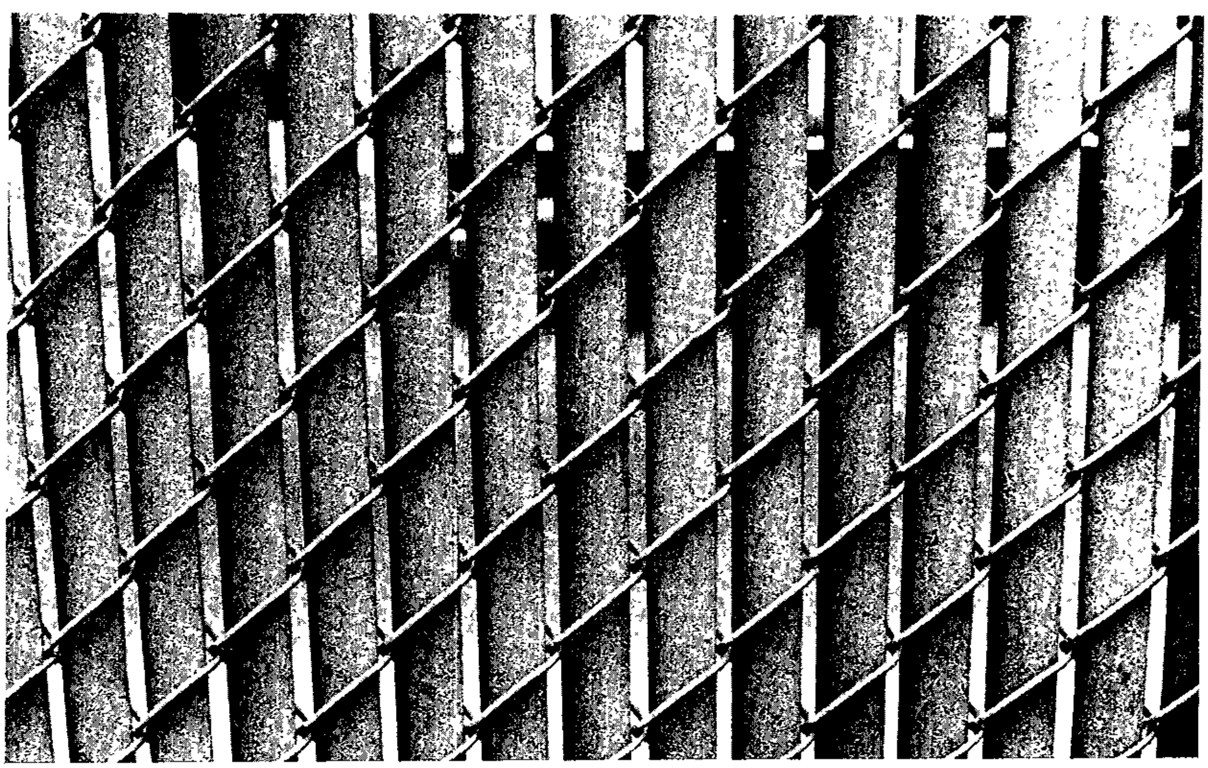
Steel tie wire and hog rings shall be galvanized.



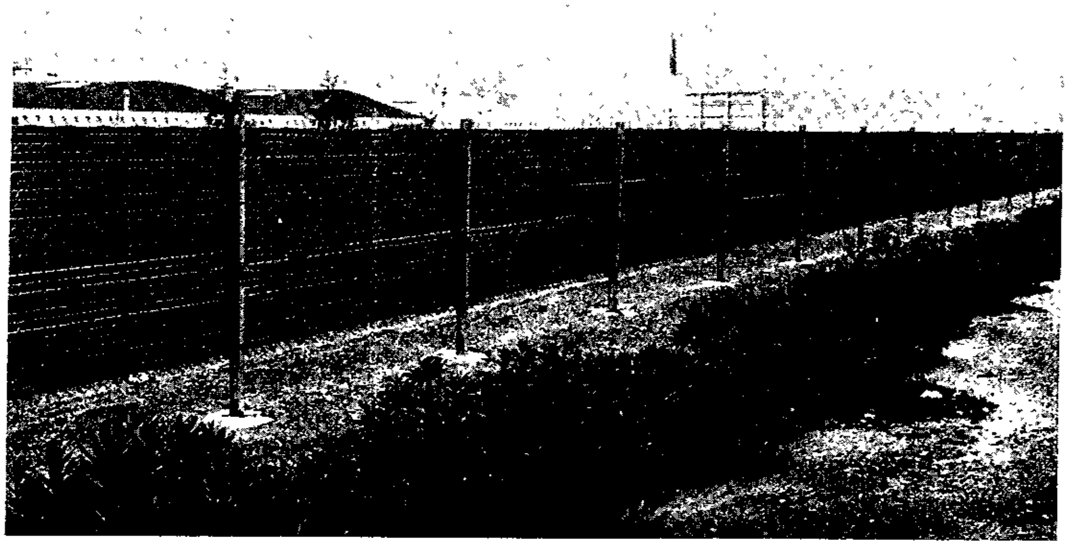


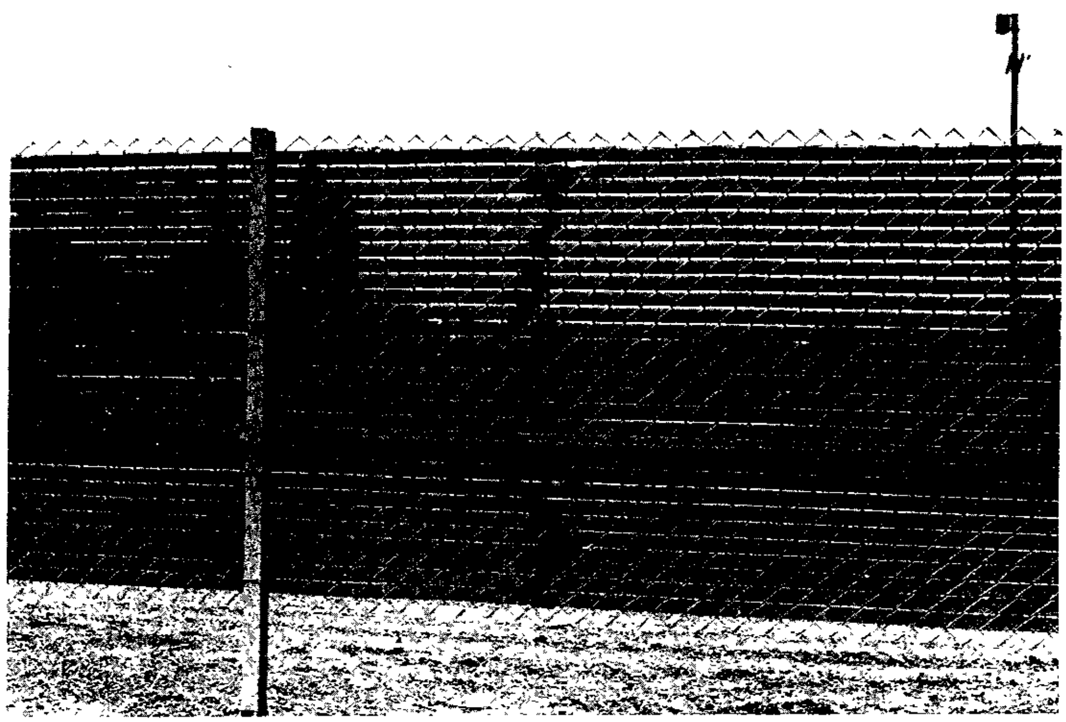
UNDESIRABLE PROPERTIES OF NYLON WEBBING



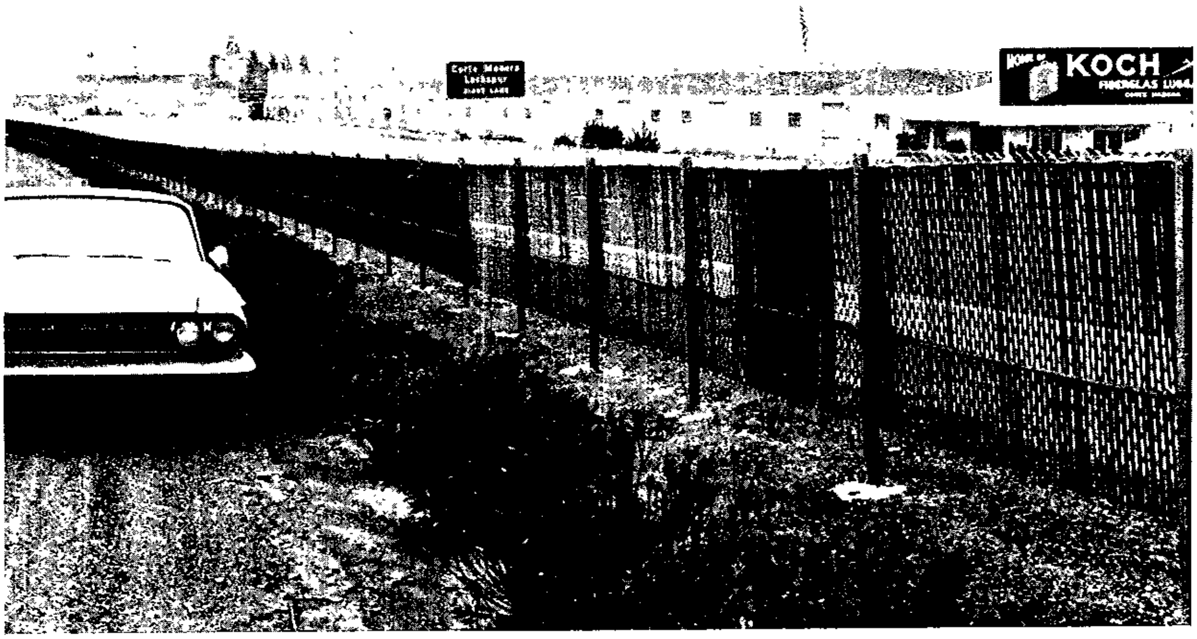


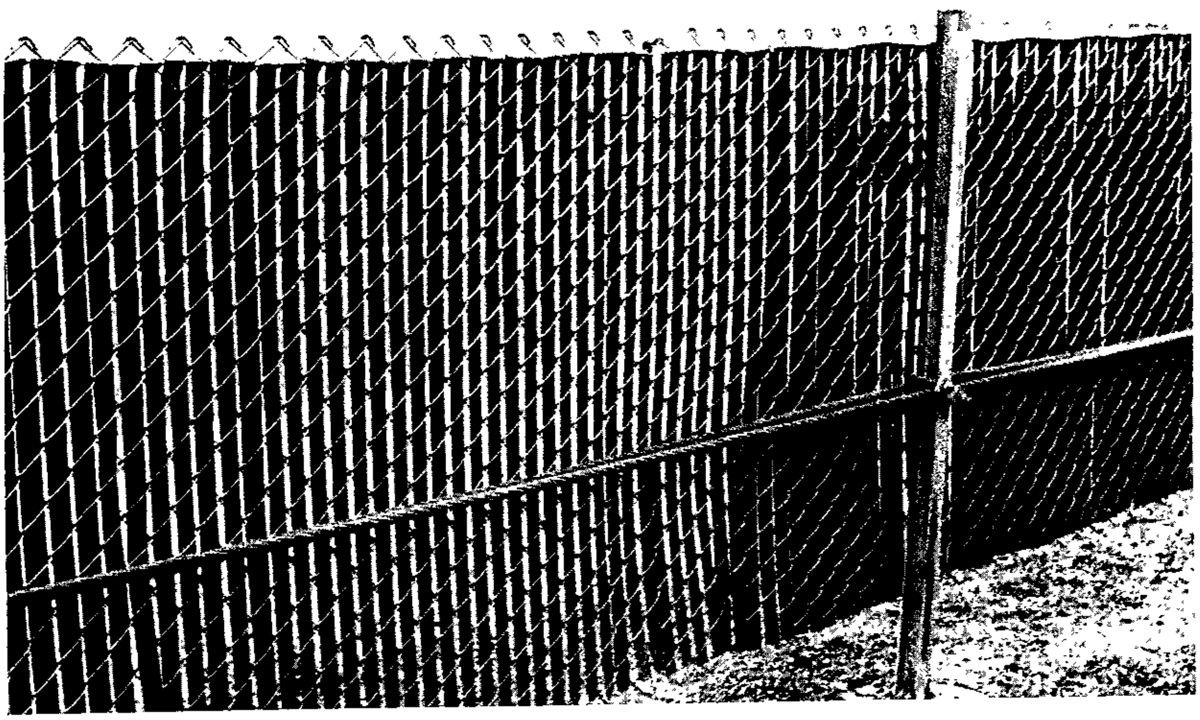
CORROSION OF AMORPHOUS PHOSPHATE-CHROMATE
COLOR-TREATED ALUMINUM SLATS



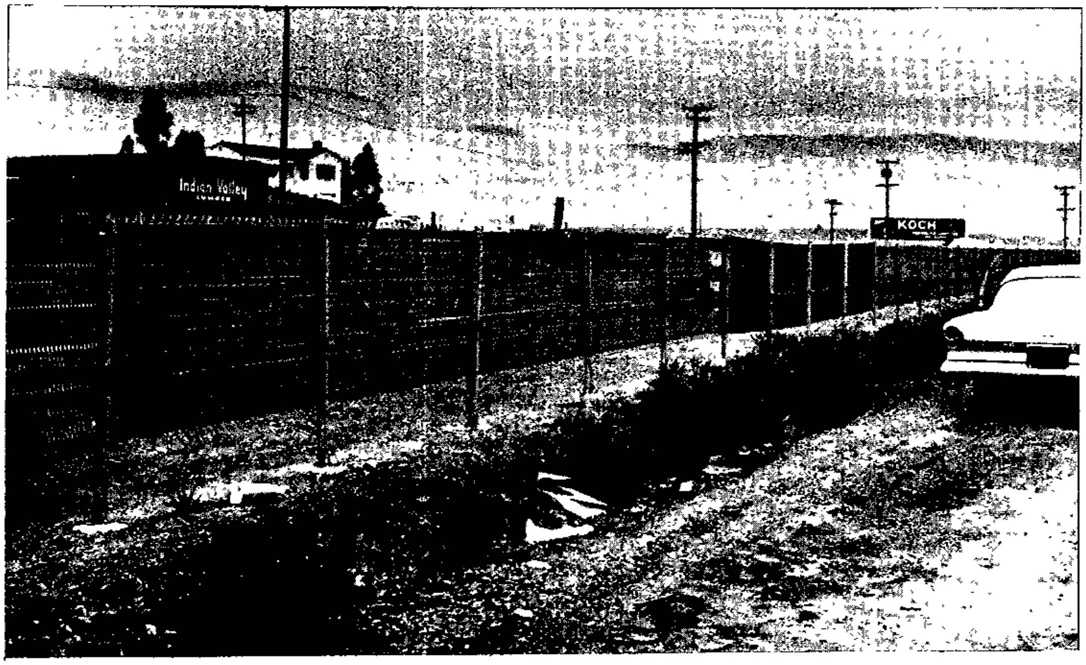


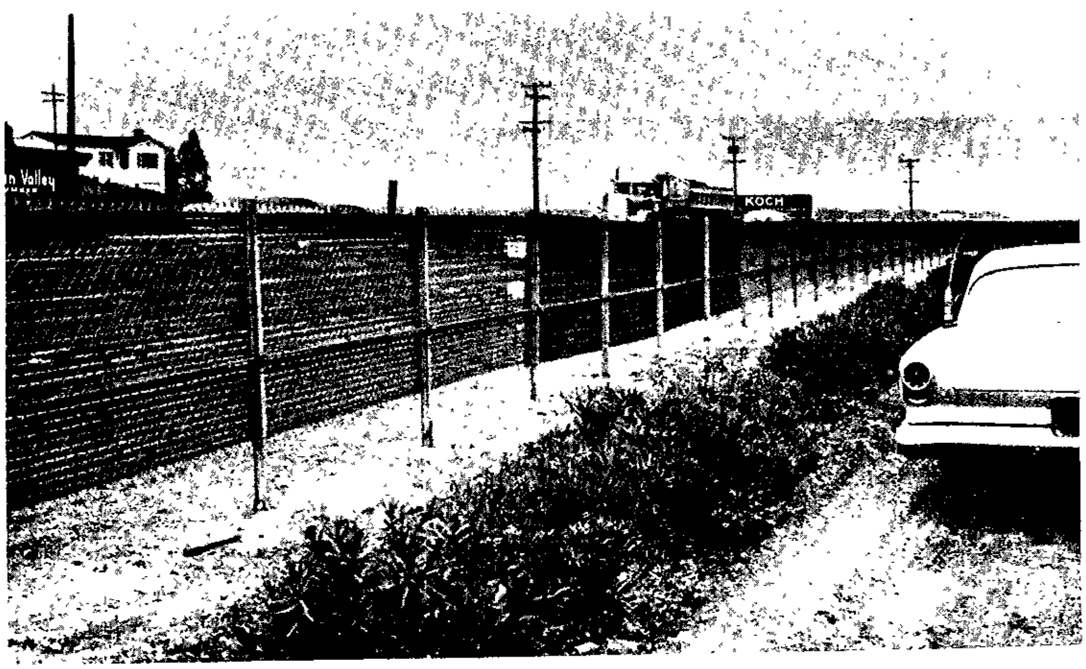
SPLICES IN POLYPROPYLENE WEBBING





POOR APPEARANCE OF ALUMINUM SLATS





IRREGULAR TOP EDGE OF EXPANDED ALUMINUM PANELS
IN REPAIRED SECTION

STATE OF CALIFORNIA
HIGHWAY TRANSPORTATION AGENCY
DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

CONTRACT NUMBER Bid 2-13-64

Marin County, between Corte Madera Creek in Larkspur and 0.4-mile south of Waldo Undercrossing (IV-Mrn-1-Lksp,CMad,C,D), a net length of about 3.5 miles, median barrier and headlight glare shield to be constructed.

SUMMARY OF PROPOSALS OPENED February 13, 1964

FOR CONSTRUCTION ON ____ STATE HIGHWAY

IN Marin COUNTY

ROAD IV-Mrn-1-Lksp,CMad,C,D

MATERIALS FURNISHED BY THE STATE: None

BID PRICE ESTIMATE OF COST

	ITEMS	Wulfert Co. Inc., Pleasanton — BID	AMOUNT	Larry W Aksland, Manteca — BID	AMOUNT	Charles E. Milleman, La Mesa — BID	AMOUNT	United State Steel Corp., Oakland — BID	AMOUNT
	Bid bond, cash or certified check accompanying bid		17 091.89		18 822.06		19 887.03		21 625.33
1.	9,210 linear feet removing chain link fence.	.35	3 223.50	1	9 210	.50	4 605	.54	4 973.40
2.	150 linear feet removing raised bars.	1.20	180	1	150	.60	90	.49	73.50
3.	Removing portions of bridge (Bridge No. 27-10).	6000	6 000	840	840	1 950	1 950	13 019	13 019
4.	102 cubic yards Class A concrete (post bases) (Bridge No. 27-10).	119	12 138	150	15 300	43	4 386	384	39 168
5.	24,000 pounds bar reinforcing steel (post bases) (Bridge No. 27-10).	.13	3 120	.1185	2 844	.23	5 520	.19	4 560
6.	17,532 linear feet cable-chain link barrier.	2.60	45 583.20	2.67	46 810.44	2.85	49 966.20	2.43	42 602.76
7.	150 linear feet single blocked-out metal beam barrier (wood posts).	5.15	772.50	4.79	718.50	7.50	1 125	5.18	777
8.	2,864 linear feet double blocked-out metal beam barrier (steel posts) (Bridge No. 27-10)	9.70	27 780.80	13.63	39 036.32	16	45 824	10.63	30 444.32
9.	95 linear feet double blocked-out metal beam barrier (steel posts) (Bridge No. 27-10)	10.15	964.25	13.63	1 294.85	12	1 140	10.58	1 005.10
10.	6,856 linear feet double blocked-out metal beam barrier (wood posts).	7.54	51 694.24	7.37	50 528.72	9.50	65 132	7.47	51 214.32
11.	1,000 linear feet cable-expanded galvanized steel mesh barrier.	4.30	4 300	4.69	4 690	4.10	4 100	4.42	4 420
12.	941 linear feet cable-expanded aluminum mesh barrier.	3.60	3 387.60	4.14	3 895.74	4.10	3 858.10	3.90	3 669.90
13.	1,016 linear feet headlight glare protection (nylon webbing coated with chlorosulfonated polyethylene).	1.55	1 574.80	4.50	4 572	1.50	1 524	4.75	4 826
14.	1,000 linear feet headlight glare protection (polypropylene webbing).	.85	850	4.50	4 500	.90	900	4.25	4 250
15.	1,500 linear feet headlight glare protection (prepainted aluminum slats).	4.50	6 750	1.92	2 880	4.10	6 150	5.60	8 400
16.	500 linear feet headlight glare protection (amorphous phosphate-chromate treated aluminum slats).	5.20	2 600	1.90	950	5.20	2 600	5.70	2 850

AWARDED TO Wulfert Co. Inc.

BY DIRECTOR OF PUBLIC WORKS February 25, 1964

SHEET 1 OF 1

65-04T13C
2463.04
CONTRACT No

FEDERAL PROJECT No. ____

FORM WH-11

EXHIBIT 16